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ASSOCIATION

MGA BULLETIN

SEPTEMBER, 1952 · NUMBER 33

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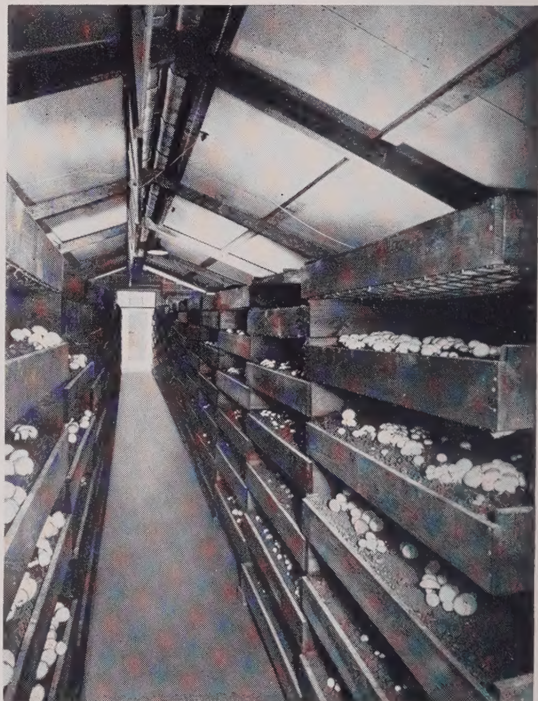

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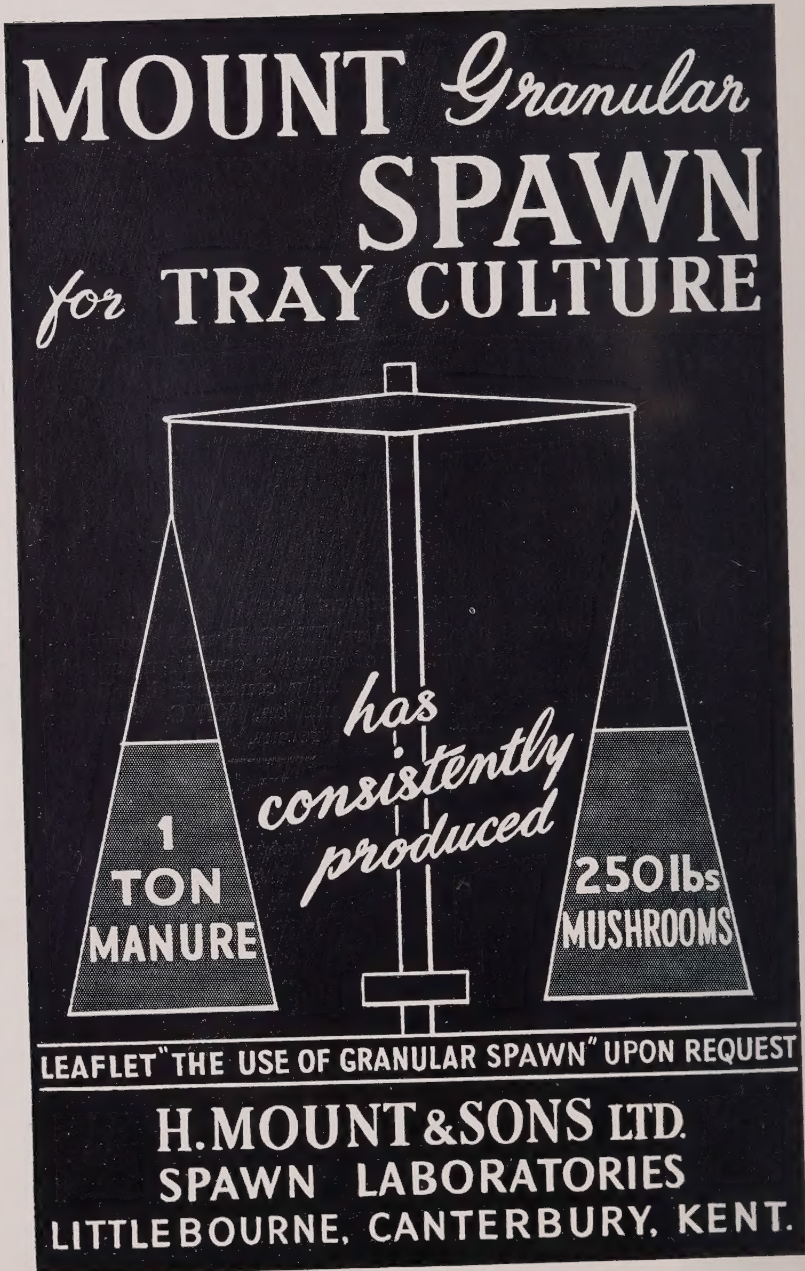
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The
MGA BULLETIN

SEPTEMBER 1952
NUMBER 33

EDITORIAL:

Dr. KLIGMAN'S VISIT

What is a typical American? Or a typical Englishman? These questions were discussed at great length, with a wealth of revelation for me at any rate, during the brief visit to Europe in July of Dr. A. M. Kligman, the brilliant American author of J. B. Swayne's "Handbook of Mushroom Culture."

Among the many fallacies widely believed is that Englishmen are excessively modest, while Americans are the reverse. Al Kligman's modesty was such that he would not agree to any publicity regarding his visit, but I did the next best thing and planned lightning trips for him to see West Sussex (with Harold Boxall), a group of growers at the Aylesbury Farm Walk on 15th July (with John Stewart-Wood) and to see Yaxley *en route* to Scotland (with Matthew Pinkerton) *via* Yorkshire (with Stanley Middlebrook).

I have asked him to write us a brief " impression " of what he saw over here. In the meantime we must be content with a remark he made to us at Aylesbury: "A gathering of growers such as this at someone's mushroom farm could never have happened in the States. **I wonder if you realise how important the MGA is, to you, to your future, and to the Mushroom Industry throughout the world.**"

The Aylesbury Walk certainly was a most pleasant and profitable occasion. About fifty members heard our Chairman explain how he had planned and equipped his Tray Farm—mechanisation enabled him to empty a 2,000 sq. ft. house, and its trays, in one hour—and after tea there was an informal discussion in the sunshine on a variety of topics. I had much pleasure in leading the talk into controversial channels, and in expressing our sincere thanks at the close to Mr. Stewart-Wood.

Fred C. Atkins.

Stanley Middlebrook's Diary

July 14th. Can you beat this note at the foot of a manure invoice ? " Owing to the very dry weather we have had to alter our terms from weight to load, but will go back to weight when conditions are favourable." Favourable for whom ?

July 16th. Why do we need 28 days to produce 1 lb. per sq. ft. on 4″ trays but only 15 days on shelves ? Air/bed ratio ? Compost depth ? Or just—the Tray System !

July 24th. I asked a question at the Refresher Course which baffled everybody: " Why did a soil which produced well when collected dry produce very badly when collected wet ? " Some light is thrown on the problem in a letter I've received from Dr. Edwards: "A recent paper in ' Soil Science ' shows that soil which has been puddled, afterwards holds a given quantity of water more tenaciously than the same soil which hasn't been puddled . . . . . . the unpuddled soil will give up more of its water to the mushroom. . . ."

July 26th. At our rate of cropping on shelves and trays I work it out that seven houses of 40′ × 18′ will produce about 1,000 lb. total more from trays than from shelves. (Remember that while all seven are used for growing mushrooms with the shelf method, only six are so used with the Tray system—one steam room of equal size needed to " feed " six growing rooms.) At 3/6 lb. this means a total extra in takings of £175. And for what ? For 2 × soil; 2 × picking time and trashing (if done); 2 × spawn; approx. 3 × watering time; 1½ × manure; tray and machinery maintenance and depreciation; large capital outlay; and a legacy of worry to be enjoyed for all time. Is it worth it ? To whom ? To those who sell soil, manure, trays, roller conveyors, spawn, etc. ? Certainly ! To the grower ? Up the garden path with roses (and mighty thorns) all the way !

Aug. 6th. It should be possible to tell which of the following telegrams came from my regular salesman: (1) " Mushrooms making 4/6—5/- Please load if possible." (2) " Mush. 2/3 Prospects better."

Aug. 7th. We are beginning to realise that different spawns need different conditions. But do we know that different spawns also *bring* different conditions ? So it seems anyway. Of those I'm trying out on an extensive scale, one which is producing a consistent 2 lb. in 5 weeks has permitted Dactylium to grow rampantly—large areas of dusty spores besides mycelium—and forced us to abandon crops at about 5½ weeks with a loss of from ¾—1 lb. per sq. ft. There is no Dactylium with the other spawns, even when they're growing in the same house. Readers please think that one out !

Aug. 8th. The Devon mushroom employee, when asked how he liked his new radio, said " 'E be fair, 'e be. But Oi doon't loike this yere chamber music. 'E groinds away 'e do, then comes News, then 'e groinds away agin and when 'e's all done 'e's only Handel's larva."

Peak-Heating by Electric Cable

*Experiments described by MYCOHM**

Whatever other advantages may be obtained from Peak Heating it is the only means known to date by which some control may be attained of Vert-de-Gris, that much-discussed disease which, in my opinion, has always caused heavy but often unrecognised losses to the Mushroom Industry.

Peak heating has always been considered impossible with ground beds but, having spent most of my life among electrical apparatus, I felt sure that something should be economically practicable on electrical lines, so some three years ago I set out to find means of raising suitably the temperature of beds laid on concrete floors in outdoor frames, and also in small experimental houses.

Despite excellent spawn runs, ideal conditions, and entire absence of obvious troubles, I often failed to get any worthwhile yields from these beds, although I knew them to be capable at times of at least $2\frac{1}{2}$ lb. per square foot. There were obvious signs, however, of Vert-de-Gris. Yields improved from the very first attempts at electric peak-heating, but a long series of calculations and costly and discouraging experiments had to pave the way to the practical and reasonably effective scheme now in use. I will mention briefly a few of the abortive lines pursued, lest others waste time and money upon them.

Early experiments were made with crudely simple apparatus, consisting essentially of light wood frames supporting a grid of exposed heating elements (at mains voltage) a few inches above the bed surfaces. These were surprisingly effective, and an immediate improvement in yields was observed. In fact, the results were among the best I have ever had, averaging around 2·6 lb. per sq. ft., but this was probably due to other factors as well. There were, however, many snags which prevented the permanent adoption of the scheme. It was only economically practicable where the air/bed space ratio was very low, as in frame-growing. Moreover, special extra heat insulation of walls and roofs was needed, in the form of temporary " quilts " of Fibreglass or the like, to avoid serious loss of heat by conduction and radiation, and practically hermetic sealing was required to prevent escape of the heated air by convection. The bed surfaces dried out completely to 1″ to 2″, and had to be well watered and forked in to restore correct moisture conditions. Lastly, the system is risky in unskilled hands, both from the shock and fire aspects.

Apart from all this, I was aware that the idea was (in common with most heating systems) topsy-turvy, and akin to trying to boil a pan of water by playing a blow-lamp on its surface. The real problem was to put the heat where it was wanted—BELOW. This, of course, was quite possible by the use of ordinary insulated heating cables, but the resulting heat was much too concentrated, and any attempt at diffusion either by mechanical aids, or by multiplication of the wiring, was

* *Nom de plume of a modest M.G.A. member*

prohibitively expensive, especially as the heaters had to lie idle beneath beds most of their lives, and were prone to serious damage at each clearing.

The alternative of a system of sub-bed watertight and non-corroding conduit, from which the cables should be withdrawn for use elsewhere, was attractive in theory, but costly in practice, and also awkward to handle. Another intriguing possibility was the use of the compost itself as the conductor and heater (on the principle used in one form of electric soil sterilizer). An elementary law of electricity is that the current, when alternative paths are open to it, divides itself, and as damp compost is more or less conductive one is tempted to assume that an ideally effective distribution would take place—the wettest parts getting the most current, and so tending to equalize the moisture content throughout the bed.

In practice, however, it is impossible to keep the compost damp enough to conduct electricity properly at all. It dries out almost immediately round the electrodes to which the supply is fed ; excessive heat occurs there as well as actual " arcing," and either the current ceases entirely through lack of moisture, or the compost goes on fire. This latter is not so improbable as it sounds ; I have had large portions of really damp beds smoulder out to ash due merely to excessive concentration of heat from sub-bed heaters in which the actual hot wire was several inches from the compost, and separated from it by fire-clay.

As the compost refused to function as a conductor, it occurred to me to regard it as an insulator (more or less !) and to lay exposed heating wires in or below it, and this led to the reasonably effective scheme now in use. For any system in which good insulation cannot be maintained between the heaters and earth, it is necessary—if using mains supply—to use transformers, both to isolate the supply from earth, and to reduce the voltage to a suitable level. Given these, there is no need for insulation, so long as there is no metal below the beds. Metal shelf scaffolding, and even metal walls, if near the beds, may however give serious trouble, although this may sometimes be overcome, but the application of the scheme to shelf systems demands an all-timber or concrete construction so far as bottoms and sides are concerned. The essentials of the idea are as follows.

Below each bed run symmetrically arranged lines of nickel chrome wire, at about 4″ to 6″ spacing, these being fed from heavy copper wire " bus-bars " at each end of each group. The voltage used depends on the length of the wires forming the groups, and a suitable arrangement can be worked out for any length of bed, the important point being that voltage balance must be maintained at adjacent points of all the wires in each group, to avoid cross currents being set up between wires via the damp compost, or earth or concrete below it. Nickel chrome wire is quite unaffected by any action of the manure, but it is very easily destroyed by electrolytic action. That is to say, it simply disintegrates if it is immersed in a conducting fluid and allowed to pass current **through** the fluid, just as does one of the elements used in an electroplating vat.

I had endless trouble with this action during experiments, especially those designed to control the heat by the use of several groups of wires in one bed, switching in and out as one does a three-bar electric fire or cooker. The sets which are off lie in the bed forming an alternative path, and part of the current in the live group or groups passes home along them, rapidly " dissolving " the wires at the points of best contact. With all the wires live, and at a good heat, and a symmetrical lay-out, this does not occur, because as soon as the current is switched on, the resultant heat dries out the materials immediately adjacent to the wires, and, in effect, the wire is lying in an insulating tube of dry matter and air. Whenever the wire cools, moisture returns, and it is impossible in practice to avoid a certain amount of cross-current leakage, with consequent disintegration of the wire, due to minor divergences from complete symmetry, and possible stray leakage from other remote units.

For these reasons, any attempts to control heat by any of the endless possible variations of voltage control by transformer " tappings," variable resistances, or complicated " series-parallel " groupings of groups of heater wires, have proved impracticable. So far as peak heating is concerned, this does not greatly matter, as the modern practice is to drop to spawning temperature as quickly as possible, and, once the desired maximum is attained, it is possible to maintain it by means of a little judicious juggling with the ordinary house heating system, and the electrical auxiliary.

With lively compost, warm weather, and good house insulation, the ordinary house heating may be able to hold the peak heat for the required period. Alternatively, the sub-bed wiring may not run the bed temperatures too high if the ordinary heating is cut off. If it does, it can quite safely be switched off for such intervals as needed, or thermostatically controlled to achieve this automatically.

It is important to bear in mind that peak heating is only fully effective when EVERY PART of the compost reaches and holds 130° F. or so, and this means that the surrounding air and all surfaces in contact with the compost must do the same. The system under review is intended only to achieve compost heating, and where the air/bed space ratio is at all high, as is often the case where ground beds are used, the normal house heating may have to be supplemented by coke braziers or electric air heaters.

With the sub-bed heaters above described, about 1 Kilowatt will normally raise 40 to 50 square feet of bed to 140° F. in from 8 to 48 hours, according to conditions. This (for the benefit of the non-electrically-minded reader) means that one unit of electricity will be used during every hour for every 40 to 50 sq. ft. of bed under treatment. To obtain as quick a rise as possible, the usual house heat should, of course, have been on prior to filling, and it may be as well also to run the auxiliary electric system for a few hours in advance to warm up the ground, but much of the benefit is liable to be lost by open doors during filling.

Very little bed moisture is lost with this form of peak heating, provided that ventilation is reduced as far as possible consistent with the prevention of roof dripping. This, however, should not be troublesome if house insulation and heating are good. In my own experience, no excessive surface moisture appears on the beds even in growing frames with a bare 6″ of air space. I have not achieved 100% results in frame-grown beds (which are sunk below ground level) because, whilst all the air and the bulk of the compost may readily be brought to 140° F., it is not possible owing to the design of the bed bottoms to get heater wires right to the outside edges, and there is always a much cooler strip of compost all round these outer parts. Even so, the 90% or so which does get full heat gives results justifying the system, and this trouble does not arise in houses where the beds are not against cold outside walls.

A point which ground bed operators sometimes miss is the influence of ground drainage. Especially on a sloping site, and if the porous soil layer is thin, and rests on impervious matter such as clay, solid chalk, or rock, a great deal of heat is extracted from the house floor (and so from the beds) by the steady seepage of water, which in winter may be at about 40° F. The best way to check this is by ditching well down into the substrata all round the house, and especially on the upperside, and draining off the water outside the building.

In conclusion I might add that the suggested system is safe, not unduly expensive to operate, and, except for the transformer or transformers, the cost of the required materials is much below that of any other scheme of which I know. Except, perhaps, for the installation of the transformer to the supply, the entire lay-out can be quickly assembled by any handy-man with some elementary knowledge of everyday electric apparatus and wiring. With care, a good deal of the nickel chrome wire may be salvaged in re-useable condition at clearing, but even if it is regarded as a dead loss, the replacement cost is low—about 5/6d. per 100 sq. ft.

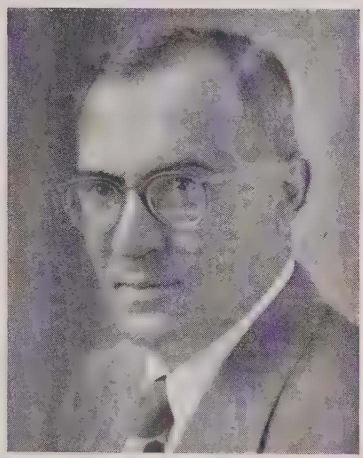
NEW (JULY) MEMBERS

Burnett, D., West Newgate Mushroom Farm, Arbroath, Scotland.
Cloke, R. H., Fearnshaw Seal Chart, Sevenoaks, Kent.
Dean & Speller, Conduit Lane, Hoddesdon, Herts.
Dumbleton, H., Wessex Nurseries, Lechlade, Glos.
Fox, J. H. Lane, Middleton House, Middleton Cheney, Banbury, Oxon.
Gadd, W. J. E., Evershed Nurseries Ltd., Holt Pound, Wrecclesham, Farnham, Surrey.
Griffin, S. D., 'La Casita,' Mount Pleasant, Biggin Hill, Kent.
Jennings, R. W., 37 Kingston Road, Leatherhead, Surrey.
Jones, Llewelyn, Glennydd, Newport, Pembs.
Kenny, C. R., 18 St. Albans Crescent, Bournemouth.
Reed, Guy, 29 High Street, Old Woking, Surrey.
Sutherland, Major G. A. B., "X" Branch, G.H.Q., M.E.L.F. 17.
Swallow, W. E. B., P.O. Box 1122, Johannesburg, South Africa.
Winslade, Miss M. G. D., 95 Stanway Road, Headington, Oxford.

CHANGES OF ADDRESS OR TITLE

Bulloch, McGregor, Hale House, Cucklington, Wincanton, Somerset.
Hansen, Preben, 65 Fox Street, Leamington, Ontario, Canada.
Kuhn & Co., Champignon-Kulturen, St. Gallen, Switzerland.
Stacey, G. J., c/o Tenterden Mushrooms, Stone Lodge Farm, Tenterden, Kent.
Wakelyn-King, J. C., 25 Kiama Street, Bowral, New South Wales, Australia.

WHO'S WHO
4—Dr. B. B. STOLLER



Dr. B. B. Stoller is known primarily in this country for his work on synthetic composts in general and the significance of trace elements in particular. He is an American scientist, married, 45 years of age, and a distinguished Honorary Member of the MGA His acquaintance with mushroom growing began in 1928-9, when he was a student at the University of Pennsylvania, next door to the mushroom centre of the United States—South-Eastern Pennsylvania. The growing of plants indoors, like an industry, appealed to his inherited interest in farming and carpentry, and his first commercial venture in mushroom growing was in 1931 in the woodworking factory of relatives in Brooklyn, New York, standing idle through the "depression."

He soon found that his interest lay in mushroom research rather than the business of growing, and as soon as funds permitted he left for graduate study at Iowa State College. It was his intention to develop a use for corn stalks in composts, and he received his M.S. degree in 1936 for a thesis on this subject. Failing to arouse interest in mushrooms in Iowa, he obtained a post with L. F. Lambert Spawn & Products, Coatesville, Pennsylvania, where he initiated a research laboratory. He continued his experiments, and results of his research on synthetic compost were published in *Plant Physiology* in 1943.

Activity in the mushroom industry practically ceased with the onset of World War II, and since he was unacceptable for military service on account of a leg broken in boyhood, Dr. Stoller accepted a research fellowship at the University of Wisconsin in 1943. He continued his research on mushrooms, and the thesis which brought him his Ph.D. degree in 1945 pertained to synthetic composts, irradiation of mushroom spores, and physiological experiments on sporophore development.

In the same year he went to Duluth, Minnesota, to conduct research on bean sprout culture as well as mushroom production. A process was developed for controlling growth of bean sprouts by the use of plant hormones, for which he was granted a patent in 1950. In addition, several hundred thousand pounds of mushrooms were produced from synthetic composts.

As a result of his work with bean sprouts he was invited to make a similar investigation into the use of plant hormones in malting. On

the completion of this project at the Pabst Brewery in Milwaukee in 1951 he returned to Duluth to his first love, mushroom culture.

Dr. Stoller writes to the Editor (20.5.52) : " I am now engaged in developing a mechanized method for composting. With this new process, it is hoped, control and regulation of composting will be exercised similar to many well-known fermentation processes in industry to-day."

It is not surprising that, in the course of his 18 years in mushroom research, Dr. Stoller has accumulated a wealth of data, and the MGA Bulletin has been offered first publication rights of an important series of articles he is at this moment engaged in writing.

The first article is entitled : *Studies on the Function of the Casing for Mushroom Beds*, and is in three parts : 1, The relation of the abnormal growth of the cultivated mushroom to fructification and casing soil ; 2, Some chemical and physical characteristics of the casing soil and their effect on fructification ; and 3, Use and characteristics of peat as a casing for mushroom beds.

We hope to publish these three parts in the October, November and December issues. They may not be the easiest reading for growers, but they will repay close study. The General Conclusions are summarised for us by Dr. Stoller below :

Explanations have been presented for some of the chemical and physical factors related to the function of the casing soil and associated with the initiation and development of the mushrooms. Some evidence has been provided, too, from experiments and practical experience. Explanations help to find out better ways of doing the same thing—they may have practical consequences.

On the basis of the explanations and evidence, a hypothesis was presented to account for the requirement of casing the beds in order to produce mushrooms, namely : the casing material acts as a medium for oxidation-reduction and base exchange reactions. Substances diffusing from the mushroom mycelium inhibit fructification unless they are modified by these reactions in the casing medium. This substance or substances have not been isolated or identified, so direct proof has not been possible at this time.

Some evidence, however, has been provided that volatile substances diffusing from the mycelium participate in these oxidation and exchange reactions. Although such evidence may be proven extraneous to the problem of fructification, still, physiological phenomena in general have been shown in recent experiments to occur through the mediation of substances hormones, enzymes, antibodies, vitamins, antibiotics, etc. Metabolic cycles have been envisioned as cycles of reactions in which several substances participate as intermediaries. Accordingly, it seems reasonable to interpret the evidence, that substances diffusing from the mycelium react like plant hormones and inhibit growth, and also serve as antibiotics to protect mycelial growth.

RESEARCH FUND, 1952

The following contributions were received in July : G. V. Allen, £5 5s. ; Housing Estates, £5 ; W. B. Randall, £5 ; Land Settlement Board, £2 2s. ; Vitax Ltd., £2 2s. ; J. C. Wakelyn-King (Australia), £1 17s. ; W. S. Galbraith, £1 1s. 3d. ; W. S. Belcher, £1 1s. ; W. E. B. Swallow (South Africa), £1 1s. ; J. E. Ady, £1 ; H. T. Gammons, £1 ; and Bankers' Orders, £30, bringing the Fund to £1,350 5s. 5d.

Reprinted from the U.S. Plant Disease Reporter, 36, 7, of 15th July, 1952.

An Improved System of Mushroom Culture for Better Control of Diseases

By **Dr. E. B. LAMBERT** *and* **Dr. T. T. AYERS**

For many years growers have recognised that the usual system of pasteurizing mushroom beds is frequently ineffective in eliminating harmful fungi, insects and nematodes from the beds. This is due to insufficient heat in the lower beds or to cold spots in the beds caused by over-composted wet manure that cannot produce sufficient heat.

Since 1949 a system of composting and " pasteurizing," developed to assure sufficiently high temperatures in the beds to eradicate most pests, has been tested in our experimental rooms. The necessary heat is obtained by raising the air temperature in the house to 150° F. and then reducing it to 105° after a few hours and maintaining this temperature for several days to recondition the compost in accordance with the principles discovered in earlier experiments (1). The yields obtained in the first experiment were sufficiently promising to warrant further tests and up to the present time four experimental crops have been harvested using the new " two-phase pasteurising " system as a basic procedure (2).

Several phases of the cultural procedure have been investigated to determine the optimum conditions for high yields. Some of the factors tested are supplemented v. non-supplemented compost, temperature and duration of the secondary pasteurization, moisture of the compost, and depth of bed. So far, the system has given very satisfactory results and tests in commercial houses have shown that the pasteurizing conditions are easily duplicated when the houses are equipped with auxiliary live steam. A brief summary follows of the procedure that, in our judgment, has proved the most satisfactory. Certain of the experimental results leading up to the development of this procedure are also included.

Plot Technique for Yield Tests. The yield tests were made in trays having a surface area of 3·5 square feet with 12 experimental treatments in each replicate block. The experiments were arranged in six randomized blocks. Sufficient compost to fill all the trays in each block was removed from the main heap and mixed thoroughly before filling to insure that the compost in every tray was as nearly alike as feasible except for the factor being tested. The recorded yields are the weights of pulled mushrooms less 20 per cent. to account for the stubs that are normally trimmed off. Statistical analyses indicated that the least significant difference, at the 5 per cent. level, between the mean yields of six replicates was usually less than 10 per cent. Except in Table 1, where individual yields are given, all the recorded yields are the averages from six replicate trays, each harvested at least 25 times. The yields for the four crops were very consistent. The seemingly low yields in Table 2 and Figure 4 are due to the shallow fills and shorter harvesting periods.

TABLE 1. Yields of mushrooms in pounds per square foot from trays filled to different depths.

Plot	A	B	C	D
1	6·33	5·19	4·60	4·04
2	6·22	4·97	4·32	3·97
3	5·79	5·56	4·27	3·70
4	6·16	4·77	4·28	3·70
5	5·71	5·26	4·48	3·67
6	5·79	4·52	4·16	3·78
Average	6·00	5·02	4·36	3·81

Note: The trays were filled at the following rates per ton of fresh manure: Those in column "A", 73 square feet per ton; " B ", 97 square feet; " C ", 120 square feet; " D ", 146 square feet; ratios on a dry weight basis are shown in Figure 1.

TABLE 2. Effect of different temperatures of reconditioning on yields of mushrooms.

Manure-temperature °F.	Pounds per square foot in 65 days
135°	2·6
125°	3·3
115°	3·6

Note: The beds were filled at the rate of 146 square feet per ton of fresh manure.

Outdoor Composting. A medium-strawy horse-manure supplemented with 150 pounds of dry poultry litter (1·5 per cent. nitrogen) and 30 pounds of gypsum per ton of manure was used for most of our experimental crops. The objectives of the outdoor mixing and composting are to distribute the supplements uniformly throughout the compost, to moisten the manure sufficiently, and to pass the compost through the initial explosive stage of fermentation. Another objective is, at the same time, to retain sufficient heat-generating capacity in the compost to insure against cold areas in the beds during pasteurization. Because indoor pasteurization is considered to be the critical part of the fermentation procedure, the outdoor composting is done as economically as possible with no regard for control of the aeration of specific areas in the pile.

The manure is assembled in elongated, wedge-shaped ricks about 8 feet high, 12 feet wide, and 20 feet or more in length. The turnings

are made with a standard composting machine so that the original shape of the rick is again approximated after each turning. During each turning the manure is scattered into the new pile at random, with no systematic attempt made to change the location of manure from the inside to the outside of the heap. The entire outdoor composting procedure is accomplished with three turnings and is usually completed in about 15 days after the first turning. During the first turning as much water is added as the manure will hold. During the second turning the supplements are added, and also water if it is needed. The third turning is made about five days before the beds or trays are to be filled, and sufficient water is added so that the moisture content of the compost will be about 70 per cent. at filling time.

The 15-day period of outdoor composting appears to be the minimum time required for proper mixing, watering, and breakdown. A longer period is undesirable since the remainder of the fermentation process can be carried out to better advantage indoors under controlled conditions.

Depth of Fill and Type of Packing. Satisfactory yields have been obtained with all depths of fill tested, from 4·6 pounds to 9·1 pounds of dry matter per square foot of bed space. The relation of bed fill to yields is shown in Table 1 and Figures 1 and 6. There seemed to be little difference between yields in beds filled loosely and beds packed (Fig. 2). We prefer a lightly packed bed. The thicker beds are somewhat less efficient in the use of the manure than thin ones but yield more per square foot of bed space. The comparative efficiency of deep and shallow bed fills is also affected by the length of the cropping period. The curves in Figure 6 will enable a grower to select the best thickness of bed and length of cropping period to suit his particular circumstances.

" **Pasteurizing.**" The pasteurizing was conducted in two phases. The first phase, at high temperature for a short time, eliminates injurious fungi, nematodes, and insects. The second phase, a comparatively low-temperature fermentation for a longer time, reconditions the compost so that it is suitable for subsequent growth of the mushroom mycelium but unsuitable for growth of the *Chaetomium* " weed mould." A schematic diagram is given in Figure 3 to compare the temperatures attained by air and compost in the two-phase pasteurizing system with those attained in the usual pasteurizing procedure.

After filling, the beds are allowed to heat naturally overnight and then steam is turned into the room to raise the temperature of the air surrounding the beds to approximately 150° F., with the temperature of the compost 5° to 15° higher. This " peak heat " is held for about six hours. Then the steam is shut off and the bed temperature is lowered rapidly to approximately 115°, with a minimum air temperature of approximately 105°. The rooms are held at this temperature from 5 to 7 days by using steam when necessary. Ammonification usually ceases in 3 or 4 days, but the air temperature is maintained at 105° for 2 or 3 additional days. Then the bed temperature is lowered rapidly to 75°.

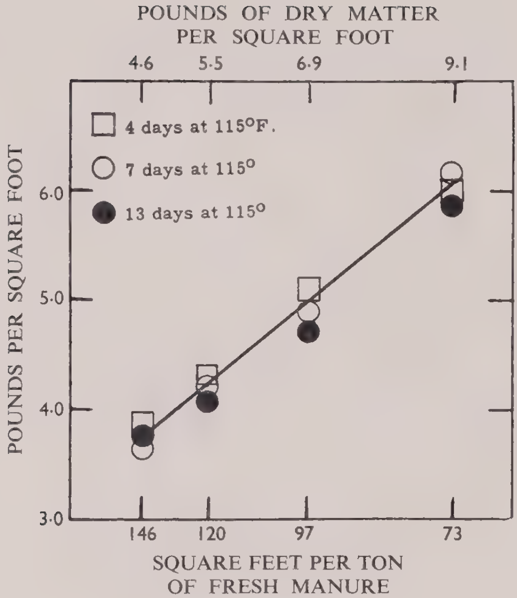


FIGURE 1. Relation of yield of mushrooms to depth of fill and duration of re-conditioning period.

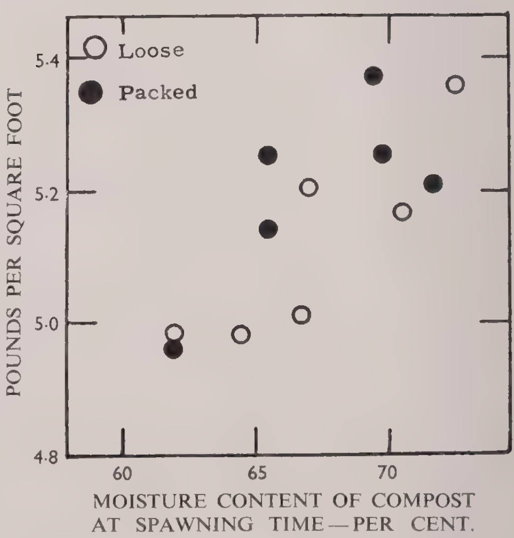


FIGURE 2. Effect of moisture content and packing on yield. (The beds were filled at the rate of 95 sq. ft. per ton of fresh manure; 90-day picking period).

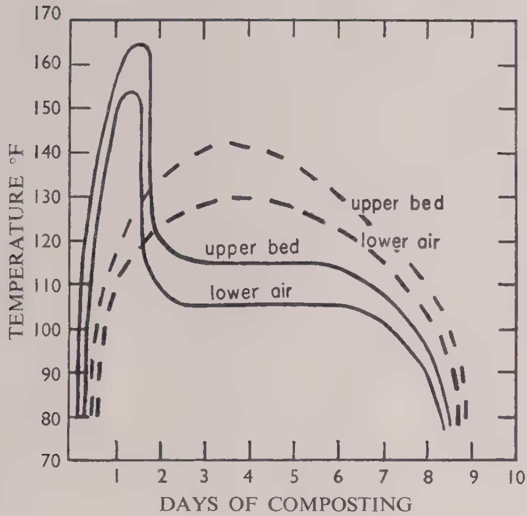
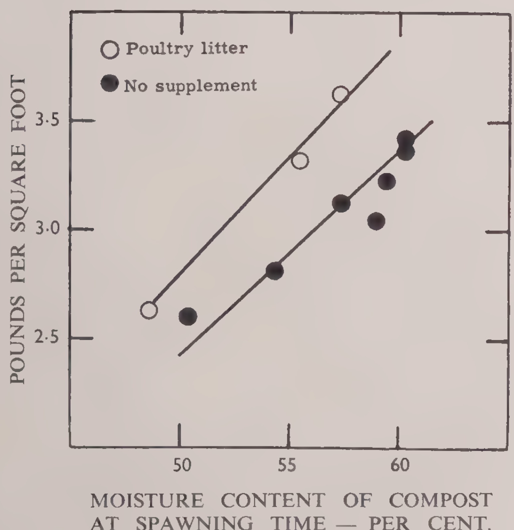


FIGURE 3. Comparison of the temperatures that the air and the compost attained in the two-phase pasteurizing system (solid lines) with those attained in the usual pasteurizing system (broken line).

FIGURE 4. Effect of moisture content of compost and poultry litter supplement on yield (146 sq. ft. of bed space per ton of manure ; 80-day picking period).



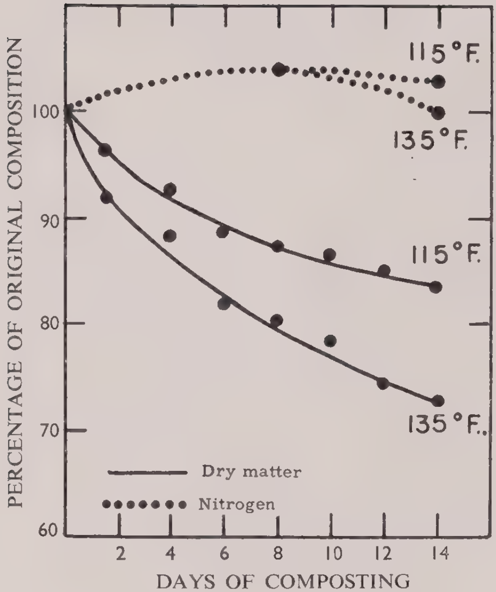
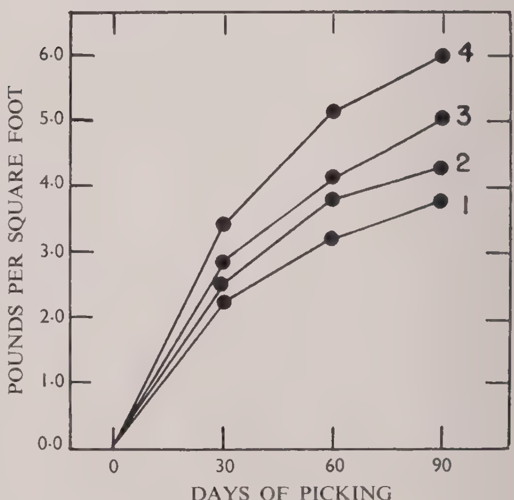


FIGURE 5. Effect of temperature on the decomposition of dry matter and loss of nitrogen in compost.

FIGURE 6. Effect of cropping period and amount of compost in the bed on yield. (The beds were filled at the following rates per ton of fresh manure: Curve No. 1, 146 sq. ft.; No. 2, 120 sq. ft.; No. 3, 97 sq. ft.; No. 4, 73 sq. ft.; ratios on a dry weight basis are shown in Figure 1).



During the second phase of the pasteurizing the low air temperature of 105° F. permits free access to the rooms for watering and the application of insecticides. The optimum moisture content of the compost is between 62 and 68 per cent. at spawning time. Yields are sharply reduced when the moisture content falls below 60 per cent. (see Fig. 4 and Fig. 2). Even with the initial air temperature of 150° the floor may not become hot enough to kill insects and mites in crevices. Therefore, the floors should be sprayed with lime sulphur or other suitable pesticide during the second phase of pasteurization. Re-infestation of the beds with flies is prevented by dusting lightly with 1% Lindane (gamma isomer of benzene hexachloride).

Earlier experiments (1) showed that mushroom compost decomposes more slowly at 170° F. than at 135°. Similar incubation experiments, in which triplicate samples of compost in pint jars were subjected to controlled temperatures, indicate that compost also decomposes more slowly at 115° than at 135° (see Fig. 5). Therefore, it seems probable that there is a considerable saving in nutrient materials in the bed throughout the two-phase pasteurization as compared with the usual pasteurizing process. The slight increase on total nitrogen, shown in Figure 5, is probably due to sampling error.

An unusual characteristic of the low-temperature fermentation is the frequent appearance of " heat mould " throughout the bed *after ammonification has ceased.* This thermophylic mould appears to be beneficial rather than harmful. It is characterized by the production of chains of thick-walled, brown, spherical spores about 9 to 16 microns in diameter. We have tentatively referred this fungus to the genus *Torula*. It is the mould that has been observed for many years appearing over the surface of mushroom beds towards the end of the sweating-out period. Incubation experiments with compost in quart jars held at controlled temperatures indicate that the fungus flora in the beds will be favoured by different temperatures in the compost during the second phase of the pasteurizing period as follows: 95° F. to 100°, *Coprinus* spp.; 105° to 120°, *Torula* spp.; 125° to 140°, *Actinomyces* spp.; 150° or over, no fungus growth followed by *Chaetomium* spp. when the beds are cooled.

The effects of temperature during the second phase of pasteurization on subsequent yield of mushrooms and of the duration of this process on yield are illustrated in Figure 1 and Table 2.

Spawning and Spawn Growth. Grain spawn is broadcast at the rate of one bottle to 60 square feet and allowed to grow about two weeks before the beds are cased. At the time of spawning the hydrogen ion concentration of the compost should be below pH 8·2 and the average moisture content approximately 65 per cent. The beds are spawned at 70° to 75° F., and the spawn is allowed to run at this temperature for five days. The temperature is then reduced to 65°, to avoid the risk of germinating " truffle " spores which may be in the compost. During the spawn run the growing rooms are closed and every effort is made to maintain a high humidity to prevent loss of water from the bed surface. We are inclined to believe that a dry layer over the bed surface at casing time tends to lower the yield. At

times we have resorted to a *very light* watering during the spawn run with no apparent harm.

Casing Practice. All the experimental beds were cased with a Chester loam that had been heated to 150° F. to eliminate pests. This soil is slightly higher in clay content than that used ordinarily for casing in Chester County, Pennsylvania, and has an undesirable tendency to puddle and form a crust when watered. Therefore, the soil was moistened before it was applied to the beds and watering was reduced to a minimum until small mushrooms appeared on all areas of the soil surface. Acidity of the casing soil was adjusted to pH 7·5 by the addition of limestone to the soil pile. Care was taken to avoid using limestone with a high magnesium content because of its toxicity to mushrooms.

Cultural Practice. During and after the first flush of mushrooms water is applied in the usual manner and the casing soil is kept moist throughout the cropping period. The beds are dusted at ten-day intervals with a mixture of 1% Parzate (65% zinc ethylene bisdithiocarbamate) and 1% Lindane in an inert carrier. This dusting programme effectively controls *Verticillium* spot and flies, and no off-taste from the Lindane has been detected in raw or cooked mushrooms. However, this dust is *definitely not* recommended for use in commercial practice until the possible residues on the mushrooms, and tolerances allowed by the Food and Drug Administration, have been determined.

Continuous, forced ventilation is supplied to the growing rooms throughout the cropping period. We believe that this is an important factor contributing to the high yields obtained. The ratio of air space to bed space in the growing rooms is about 6 cubic feet of air to 1 square foot of bed. The air is renewed at the rate of 10 cubic feet per hour per square foot of bed space.

The temperature during the cropping period is held at approximately 60° F. The effect of the length of the cropping period on the yield of mushrooms is shown in Figure 6.

Factor Interactions. Four of the experiments were arranged so as to permit the simultaneous expression of the effect of the following paired factors on yield: depth of bed and duration of the second phase of pasteurization; packing and moisture content of compost; poultry manure supplement and moisture content; and packing and depth of bed. In some cases the separate and cumulative effects of the factors were clearly evident, but there was no clear-cut evidence of factorial interaction.

Tests in Commercial Houses. The two-phase system of pasteurization was given its first commercial trials in 1950 in the houses of the Brandywine Mushroom Company, West Chester, Pennsylvania, and of the Keystone Mushroom Company at Coatesville, Pennsylvania. Following these tests the system was used to prepare the compost for several hundred thousand square feet of bed space in these two establishments. It is evident from the experience gained in these houses that the system can easily be followed in commercial houses, provided an adequate source of auxiliary steam heat is available to attain the initial high pasteurizing temperature, and the houses are in good

condition so that they will not be effected by this high heat. Increased yields of between 1/2 to 1 pound per square foot were obtained in commercial houses, but so far the increases have been disappointing when compared with the yields obtained in our pilot plant.

Discussion and Conclusions

The system of mushroom culture described above has been followed in four successive crops in our experimental growing rooms. The first objective that we set out to achieve has been attained; namely, the development of a system of pasteurizing that would enable the grower to raise his bed temperatures above 150° F., but keep his beds free from *Chaetomium* during spawn run. Such a system has obvious advantages in the control of harmful fungi, nematodes, and insect pests in the beds.

In our experimental rooms, yields of 5 pounds per square foot were obtained in beds filled at the rate of 97 square feet per ton of fresh manure. Yields of 6 pounds per square foot were obtained in beds filled at the rate of 73 square feet per ton. These yields are surprisingly high when compared with commercial yields. We are inclined to attribute the high yields to the accumulative effect of a number of favourable factors:

1. A poultry litter supplement seems to add about ½ pound of mushrooms per square foot to the yield.

2. The shorter outdoor composting (15 days), the high initial heat, and the comparatively low temperature of the second phase of pasteurization conserve carbonaceous material and possibly other essential nutrients.

3. The high temperature of the first phase undoubtedly eliminates most of the known harmful organisms and possibly some which have not been investigated.

4. The low temperature of the second phase is beneficial, probably through favourable nutrient changes and the conservation of moisture in the bed. *Torula*, a fungus which is very conspicuous at the end of this phase, appears to be associated with high yields.

5. The comparatively high heat-generating capacity of the compost, due to its " greenness " when placed in the beds, permits an aerated pasteurization of compost of high moisture content. The optimum moisture content of the compost at spawning time apparently is also somewhat higher than that of compost prepared in the usual manner. In this respect, it seems to be comparable to compost prepared by Sinden's method.

6. The continuous forced ventilation in our growing rooms provides an adequate supply of fresh air at all times.

7. The pasteurization of the soil undoubtedly reduces the population of harmful organisms.

8. The use of Parzate and Lindane on the surfaces of the beds permits continuous and extended cropping at approximately 60° F., with a minimum of accumulated diseases and pests. The use of Lindane is *definitely not* recommended for use in commercial houses until the Food and Drug Administration has set up tolerances for it.

As mentioned previously, the few commercial growers who have

tried the " new " system have encountered no difficulty in following the temperature cycle during pasteurization, but the small increase in yields in commercial houses has been disappointing. The reasons for the failure of commercial growers to obtain yields commensurate with our pilot scale tests have not been cleared up. It seems probable, in the light of the investigations of Middlebrook and Storey (3) and Storey and Edwards (4), that inadequate ventilation in commercial houses is at least one of the important limiting factors.

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Editorial footnote. We suggest that any grower who might be inclined to rush excitedly into the practical application of this new system would be well advised to consider carefully the **warnings** mentioned in the article and those that follow. The latter are taken from a letter received from Dr. Lambert since the article was printed.

While astonishingly high yields were obtained consistently in experimental tests, the authors state clearly above that under commercial conditions yields were disappointing and that they are unable to explain why this should be so. In his letter, Dr. Lambert enlarges on the warnings in the following terms (which he allows us to quote) :

"Although we would certainly use this system ourselves if we were engaged in commercial culture we do not urge growers to use it. We prefer to tell them that we like the system but consider it by no means foolproof and that they should consider it in the experimental stage and try it first on a small scale . . . . . . The need for an auxiliary source of heat during pasteurization is clearly a limitation. Also, the interdependence of several factors such as high temperature pasteurizing followed by low temperature, comparatively green manure to assure high temperatures in the bed, etc., is somewhat of a disadvantage. This is true because we feel that the system will only be effective when carried out properly in all phases. In other words, we may have contributed to the complication of mushroom culture rather than to its simplification. In listing disadvantages I must not forget to mention that one grower found that the high heat softened his upright bed supports to such an extent that his beds collapsed. For some strange reason he did not consider this a minor incident ! . . . . . . The high yields will no doubt appeal to growers but they still have us puzzled."

As, on Dr. Lambert's admission, composting times and duration and temperature of pasteurizing were chosen upon empirical grounds, there is much more experimental work to be done before the system can be regarded as " safe."

Dr. R. L. EDWARDS surveys

RESEARCH IN WESTERN EUROPE

During the last three years new organisations for research on mushrooms have been set up in Belgium, France, and Germany and the study of air conditions has led to the building of several mushroom houses with air-conditioning in Holland. Some French growers are also carrying out their own programmes of research and development.

Many of the research workers at these centres have visited Yaxley and I was glad to have the chance earlier this year, to return their visits and see what they are all doing. I received a warm welcome, and I think anyone else genuinely interested in their work would be equally well received. Much of the research work is of course rather technical in nature, but the problems chosen, general line of investigation, and progress made or to be expected must interest British growers.

HOLLAND :

Unfortunately the laboratory at Houthem where Dr. and Mrs. Bels worked has been closed, and they have now moved to Canada. Their researches on fruiting of the mushroom and the effect of casing soil have stopped, but the study of air conditions in mushroom houses, in which Dr. Bels was concerned with Messrs. van Keulen and Spoelstra, will be continued at the Institute of Horticultural Engineering at Wageningen under the direction of Dr. E. W. B. van den Muijzenberg. Miss Kleermaeker who was at Houthem with Dr. Bels has moved to Wageningen to help with the growing side of experiments there.

I saw skeleton buildings going up in which sections of wall can be built or lined with various materials and instruments will be installed to compare their merits as insulators for mushroom growing houses and heat rooms. There are also various kinds of doors and fastenings on trial to find which give the best air-seal. The Institute is just moving into new quarters and this work is only in the preliminary stage. They hope to restart work on other mushroom problems later. There is also some interesting research on methods of heating, with a comparison of low pressure steam pipes, 4″ hot water pipes with gravity circulation, air warming with forced circulation, and $\frac{3}{4}$″ hot water pipes with forced circulation. They find that this last method is most economical in fuel consumption, is easy to control, and gives less corrosion than steam.

They took me to see several of the air-conditioned houses in use, some with shelf beds and others with trays, but not on the two zone tray system. The houses are heated by continuous forced circulation of the air through a coke-fired stove in a small room at one end of the house. There is provision for admitting a proportion of fresh air controlled by adjustable dampers.

The air is humidified by a small accessory boiler also coke-fired, which delivers steam into the circulating air stream. This is not completely satisfactory in practice, because the boiler cannot be controlled

accurately enough to maintain the desired humidity ; there is a tendency to introduce too much moisture, and some growers no longer use this part of the air-conditioning system. Experience with these houses has shown that air inlets must be large enough to give low air speeds, and must be so placed that air does not blow directly on to the beds, nor against walls or ceilings from which it would be deflected directly on to the beds. The size and position of outlet ducts is less critical. One duct is usually in the form of a channel under the floor and this has been used for either inlet or outlet in different houses.

Circulation of air within the house is also being investigated. In the ordinary mushroom house this is virtually uncontrolled and depends on convection currents caused by differences in temperature. We really do not know whether or how this can be improved upon.

BELGIUM :

The Belgian Centre of Mushroom Research forms part of the Agricultural Institute at Gembloux, and has the benefit of the part time services of some of the Institute staff. The mushroom research programme is directed by Professor Willam, assisted by M. Heinemann, M. Autryque, and Mlle. Engels. They also do some advisory work for growers.

The Centre is very well equipped for small scale cropping experiments, with three cellars for experiments on floor beds, shelves, and trays.

All three cellars are electrically heated, and water troughs are fitted over the electric heating tubes, so that the humidity can be artificially raised if necessary.

The shelf beds are of concrete with low voltage heating cables embedded in them, as well as the air-heating tubes. All heaters are thermostatically controlled.

Research on casing soils has started and when I was there mixtures of clay, sand, ashes, and broken brick were being prepared to case a set of trays. Physical tests were also to be carried out on these mixtures.

Their other main project is a study of other fungi closely related to the ordinary cultivated mushroom, in an attempt to find one similar enough in appearance but less critical in its requirements for fruiting. About 30 fungi are maintained in pure culture for this purpose. It is a long-term project and the results are unpredictable, but if successful it could revolutionise mushroom growing as we know it to-day.

Apart from this they are investigating the effect of growth substances in pure culture, and hope to extend this to the fruiting stage.

FRANCE :

I was particularly pleased to be a guest, with Mr. J. Stewart-Wood, Chairman of the MGA and MRA, at the Research Day of the French Mushroom Growers' Federation which was attended by about 200 members.

They held a meeting at which reports were presented on the programme, finances and preliminary results. The discussion centred mainly on the most urgent problem facing mushroom research centres

in all countries—finding the money—a problem which is solved in different ways in various countries, but always with difficulty.

The discussion was followed by a lunch at which we had the pleasure of seeing well-earned Decorations awarded to two of the Officers of the Federation. M. G. Guelinel, representing the French Minister of Agriculture, created M. du Roselle, Treasurer of the Federation, " Chevalier de l'Ordre du Merite Agricole," and M. Dekeirel, Secretary of the Federation, " Officier " of the same Order. The awards were received with loud applause by all present.

After lunch we went to the Experimental Station at St. Cyr to see experiments in progress, results obtained, and the Exhibition arranged by the Federation. The Experimental Station has four small houses cut into the hillside, originally for gun emplacements. Cropping experiments are planned by M. Delmas and carried out by M. Bouillon, using trays which can be pasteurised, humidity being maintained by means of a gas fired boiler.

Experiments at St. Cyr have so far been concerned with supplements to horse manure and the pasteurisation process, and with casing soil. It has long been the custom in France to add sulphate of ammonia to their manure ; this and other supplements are now being critically examined to find the best way of using them. Pasteurisation is new to them and cannot be applied to their normal type of ridge beds on the floor.

Experiments at the Experimental Station may be followed by commercial use. If this follows the general practice of those American growers who use the Tray System in caves, it will involve considerable development because most French growers at present concentrate on simple methods with the minimum of handling, whether manual or mechanised. A few leading growers are installing trays, some for use with the accepted Tray System, others intending to pasteurise the trays and then turn out the compost into floor beds. The Experimental Station has no caves large enough to experiment with this last method.

The commonest casing material in France is the powdered stone of the caves, either alone or mixed with some imported soil. Their casing is always fairly fine, and indeed must be, to stay on the ridge beds.

The Exhibition included stands offering spawn, insecticides and fungicides, pumping and other machinery. BHC was the principal insecticide shown, zineb and hydroxyquinoline sulphate the main fungicides. Some firms offered mixed preparations containing both insecticide and fungicide. Parathion was also shown and recommended for application to newly laid beds to control mites.

A machine which would have been most interesting had not arrived from Germany in time for the Exhibition. It was a rotating hydraulic grab to be mounted on a tractor, so that compost could be lifted from a stack and fed to a turning machine without moving the tractor for each load, as must be done with a fork lift.

During the previous few days the President of the Federation, M. Guiochon, showed me his caves and the pasteurising room he is installing, M. Sarazin showed me round his caves and beautifully

equipped spawn laboratory, and M. Delmas took me to the Central Agricultural Institute at St. Cyr, directed by M. Boischot.

GERMANY :

Quite a new field of mushroom research is being opened up by Dr. Rempe at the Glasshouse Research Station at Essen. He is developing a compost based on sawdust which has given yields up to 1.6 lb. per sq. ft. from flat floor beds in heated underground air-raid shelters. The object is to use this type of compost for winter mushroom growing in glasshouses in North Germany. The principal nutrient added is nitrogen, at 1.8% of the dry weight of sawdust, and this may come from brewers' grains, malt culms, whey, corn steep liquor, or a sludge from brewery fermenting vessels. Phosphate, potash, and lime are also added. The sawdust is soaked by three successive waterings and is then mixed with these fertilisers in a pile about three feet wide and two to three feet high, with sloping sides. The heap is turned after 3-4 and 6-8 days and is ready in 10-14 days, under their conditions, composting underground with no draughts and high humidity so that little heat is likely to be lost from the pile. Sometimes the pile is made over an openwork arch about six inches high to provide aeration along the bottom.

The compost is very easy to handle and is uniform in texture. The floor beds are about eight inches deep. They are spawned and cased in the usual way, and come into crop about five weeks after spawning in heated cellars. They are exhausted in about 2 months. A ton of dry sawdust, usually soft wood, makes enough compost for 330 sq. ft. of bed.

In view of the recent shortage of wheat straw, and the difficulty of getting it at any time in the North, a satisfactory compost from sawdust would be most useful, and preliminary experiments are to be carried out at Yaxley.

It is quite clear from the visits I made that there is and will be in future years much for us to learn from the Continental Mushroom Research Centres, and there is all the goodwill needed for the exchange of information and ideas essential to maintain a healthy and progressive industry.

"**The Microscope** in Industry and Research" Exhibition at the New Horticultural Hall, Westminster, on 15th September (2-6 p.m.), 16th-19th September (10 a.m. - 6 p.m.) includes "Some diseases of the cultivated mushroom."

A list of tools and miscellaneous requirements for "the smallest commercial mushroom farm capable of being run as an economic unit" has been compiled for the MGA by J. Watts. Copies are available free, from the Secretary.

Sussex Successes : All the winners in the Mushroom Classes at the Sussex County Show at Midhurst in July were MGA members. Congratulations to Raymond Thompson (East Wittering) on his two firsts, to R. J. Hopkins (Horam) on a second and third, and to Mrs. R. M. Hopkins (Horam) on a second.

THE CULTIVATED MUSHROOM–5

Germination of Spores and Development of Mycelium

By **ANDRÉ SARAZIN,** Licencié ès Sciences

Since the discovery that the basidiospores of the cultivated mushroom germinated was reported in 1893 by Matruchot and Costantin, this method of producing spawn has been much developed ; trips to the countryside in search of " virgin spawn " are now, for the mushroom grower who is ripe in years, but a memory of youth.

If the basidiospores (or simply, spores) are sown in sufficiently dense masses, they germinate on suitable culture media at 28° C. (73.4° F.) in five to ten days according to the strain cultivated. In the same spore harvest the germination percentage varies considerably according to cultural conditions. In principle, a spore which is isolated from a spore harvest does not germinate, nor likewise does any spore isolated directly from a basidium. When sown collectively the most vigorous are the first to germinate and quickly give rise to a mycelium ; furthermore, according to my observations, those which have not already germinated lose their power to do so in the presence of this mycelium ; the germination percentage is therefore relatively low. If, on the other hand, at the end of the time interval required for incubation (usually 4 to 5 days), the precaution has been taken to make a dilution which would result in each spore being separated from its neighbour by a distance estimated at 4 or 5 times the diameter of a spore, the percentage spore germination forty-eight hours afterwards reaches its maximum (more than 80%). Fig. 1.

Briefly, then, the spores of the cultivated mushroom, and likewise of all fungi, germinate better when sown collectively than when sown severally. When a collection of spores is sown the young mycelial growth from the spores inhibits the germination of tardy spores. If, on the other hand, a dilution is made at the end of the period necessary for collective spore incubation, germination reaches the maximum percentage ; there seems to be, therefore, during the incubation of the spores, an excretion from spores of a substance which diffuses into the medium and which stimulates the germination of the spores ; this substance would seem to be destroyed or inhibited as soon as the mycelium develops.

All attempts made by me to extract this substance from even considerable quantities of spores as well as from germination media rich in vitamin preparations (aneurin, inositol, β-alanine, bios, etc.), while they have enabled me to bring about a significant increase in the percentage germination, have not enabled me to bring about the germination of a spore isolated singly either from a spore harvest which had not been incubated previously or directly from a basidium.

The viability of the spores is considerable. When well dessicated they remain viable for several years (3 to 5) but germination frequency decreases rapidly with age.

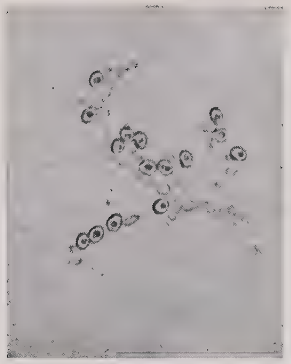


Fig. 1
Photomicrograph magn. × 450

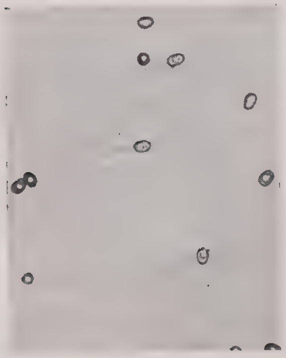
Fig. 2
Photomicrograph magn. × 450. Germination of spores from production of vesicle to branched tube

Germination of the spore commences with the appearance of a small clear rounded vesicle which emerges from a minute pore in the spore wall. Sometimes spores are observed which produce two or three germination vesicles but, according to my own observations, only one one of these proceeds to develop into a germ-tube, the others being abortive.

As a result of cytological investigations on fixed material treated with nuclear stains, I consider that the living material poured into these aborted vesicles is incapable of growth because it does not contain nuclei.

The normal vesicles enlarge to the size of the spore, whereupon they grow out into a tube (figs. 2 and 3) which, while it continues to grow, branches in various directions (fig. 4) constituting the rudiments of the future mycelium.

I have also observed that if germination takes place on a solid medium containing an excess of agar (30 gr. per litre) and dried slightly,



Figs. 3 and 4
Photomicrographs magn. × 450. Germination of spores from vesicle to branched tube

the vesicle which grows out into a germ-tube may become relatively large (four or five times the diameter of the spore) whereas in a dilute liquid (not containing agar) the vesicle becomes transformed immediately into a germ-tube ; I therefore consider that the germination of the basidiospore takes place in two stages.

In the first stage, after incubation at 23° C. (73.4° F.) for 5 or 6 days, the basidiospore absorbs water, mobilising by means of hydrolysis the reserves which it contains in order to empty them through the germ-pore into the vesicle along with some living substance.

In the second stage the living substance in the vesicle finds at hand in the surrounding medium the materials necessary for its growth, absorbs them, assimilates them and proceeds to grow.

Clearly then, when the medium contains only a small amount of agar or else is fluid, these interchanges with the surrounding medium are accelerated, thus enabling the rapid building up of new living substance, whereas on a medium containing much agar which retains its water content tenaciously, the small amount of living substance which is emptied into the vesicle absorbs only slowly the nutritive materials in the medium. As a result of this the living substance has time to assimilate the reserves which are contained within the spore so that the osmotic pressure and turgidity of the vesicle are increased and it enlarges considerably. The turgidity of the vesicles is shown by the extreme fragility of the vesicle wall which bursts at the slightest contact with a micropipette manipulated by means of a micromanipulator. As soon as the primordial germ-tube lengthens, profuse branching occurs. The branches themselves then multiply and fuse with one another to produce a tuft in the centre of which lies the spore (fig. 5).

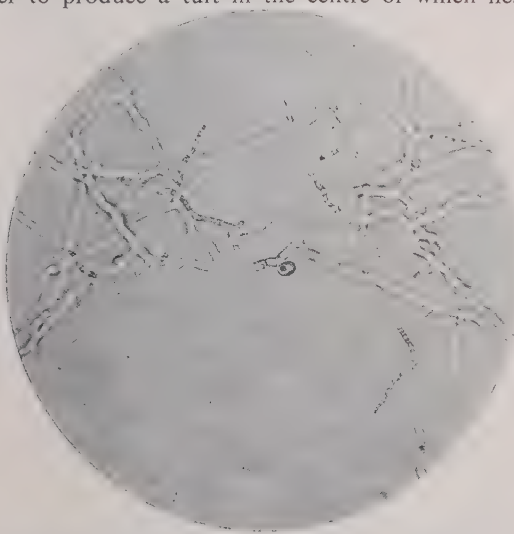


FIG. 5. Photomicrograph magn. × 450. Mycelial tuft developing around centrally situated spore

When several spores germinate side by side their germ-tubes join together. This can in no way be interpreted as a sexual process as will become evident in the cytological discussions which follow later.

It is at this stage that the mycelium is propagated in previously sterilized medium to be used by mushroom growers for spawning, sterilisation of the medium being effected by a variety of methods.

Mushroom spawn, whatever the shape or form it may take, represents therefore only a stage in the life-cycle of the cultivated mushroom which is intermediate between the germination of the spores and the development of the mycelium in the bed. In this connection it should be mentioned that it is quite easy to obtain mushroom spawn by pinching off aseptically small pieces from the false tissue of the mushroom or from the hymenia of young carpophores, but this procedure tends to be followed less and less as it produces spawn which is very erratic as regards its vigour and fertility.

To recapitulate, the spawn which is laid in the beds ' runs ' and develops radially downwards from a central inoculum. The fringe of the mycelium is growing ceaselessly as the cytoplasmic pressure causes the mycelial threads to become increasingly longer. On the other hand the central portion, representing the inoculum, ages ; here the mycelial threads grow together in increasingly thicker strands which become interwoven in the casing-soil at the time of casing.

Considered in a microscopical sense, the delicate threads seem to disappear into the gradually thickening strands in much the same way as separate threads are woven into a rope. The formation of mycelial threads indicates the initiation of the carpophores. In short, this constitutes the transition of the vegetative mycelium to reproductive mycelium.

In the bed, the formation of the strands takes place as soon as the mycelium has filled up all the vital space around the piece of spawn and its growth begins to slow down. Nevertheless, it must not be concluded that this is the only factor responsible for their formation. A relative ageing of the mycelium is necessary before it is able to accummulate the necessary reserves in adequate quantity for the formation of the fruit bodies. Thus, if the mycelium is afforded the opportunity of indefinite growth in a part of the bed in which only one piece of spawn has been laid, a time comes when it will bear fruit on the site of the piece of spawn while in its peripheral portion it is in a state of active growth.

Laying the spawn too closely does not accelerate fruiting, while on the other hand laying it at too great space intervals retards it. The mushroom grower has, by leaving a space interval of 7-8 inches between each piece of spawn, succeeded through practical experience in bringing into evidence the possibility of combining the two factors which are operative in producing early fruiting, viz. enabling the invasion of the space interval between the pieces of spawn by mycelium to be completed in the time required for the same mycelium to accummulate the materials used up in the formation of the fruit bodies.

Excessive moisture in the compost (more than 60%) stimulates rapid production of thick mycelial strands whereas, on the contrary, excessive dryness retards it.

More or less indifferent preparation of the compost is liable to retard the growth of the spawn at the stage of strand formation and the mushroom grower as he vainly awaits the appearance of the fruit bodies observes on opening up the bed that the spawn is spent and shows only here and there a few thick strands. In less unfortunate cases the fruit bodies appear only on the pieces of spawn ; the mycelium has not progressed far into the bed and it does not accummulate sufficient food material to ensure an uninterrupted harvest.

Reference

COSTANTIN (J.) AND MATRUCHOT (L.), 1893. Sur un nouveau procédé de culture du champignon de couche. (On a new method of growing cultivated mushrooms). C. R. Ac. des Sc. *Vol. CXVIII*, 3rd July, 1893, p. 70.

The translation is by Dr. C. J. La Touche. The blocks are the property of the Author. Permission to reproduce has been obtained from the Author and from the Editor of the French Federation's Bulletin.

See You on October the First!

Mr. John Hensley, Head of the Horticulture Division of the Ministry of Agriculture, has kindly consented to be our Guest of Honour at the **Annual Mushroom Lunch** at the Connaught Rooms, London, on Wednesday, 1st October.

Mr. Hensley is 42, married, and has a son aged three. Educated at Malvern and Trinity College, Cambridge, he has been at the Ministry since 1933, except for a period in 1939 and 1940, when he was Private Secretary to Mr. W. S. Morrison (the present speaker) when Chancellor of the Duchy of Lancaster and later Minister of Food. Also, he was Private Secretary in 1945 to two successive Ministers of Agriculture, Mr. R. S. Hudson (now Lord Hudson) and Mr. Tom Williams. Since 1946 he has been Assistant Secretary to the Ministry of Agriculture, and in 1950 he succeeded Dr. V. E. Wilkins as Horticulture's Chief. (It was Dr. Wilkins who, as Guest at our memorable First Lunch in 1946, publicly " recognised " the mushroom crop as *an integral part of the horticultural industry*.)

Photo : The Grower

Our Chairman, Mr. John Stewart-Wood, will be at the Connaught Rooms (in Great Queen Street, off Kingsway) for the **Reception** at 11.30 a.m. As in the past, this will provide an opportunity for members and friends to meet socially over an *aperitif*.

Lunch is timed for one o'clock. The **Annual General Meeting** follows at 2.30 p.m.

Retail Packs for Mushrooms

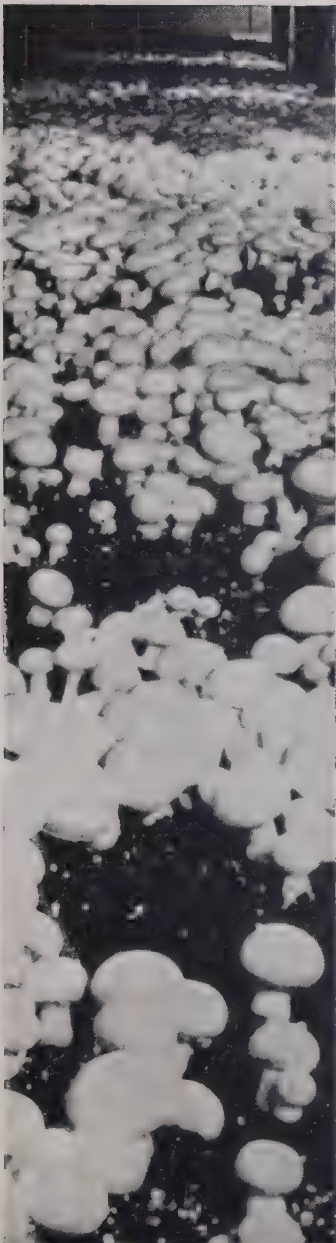
Window cartons, punnets, and boats, suitable for marketing mushrooms in retail units, are being produced by The Metal Box Co. Ltd., of The Langham, Portland Place, London, W.1. They incorporate 'Clarifoil,' the transparent cellulose acetate film manufactured by British Celanese Limited, and the two companies working in close co-operation have developed them to meet the specialised requirements of the fruit and vegetable trades.

The punnets, which are available in $\frac{1}{2}$ lb. or 1 lb. sizes (they take $\frac{1}{4}$ lb. and $\frac{1}{2}$ lb. of mushrooms respectively), have detachable transparent lids ; the boats are over-wrapped with 'Clarifoil' after packing, and are completely dust and waterproof. 'Clarifoil' is not moisture-vapour proof, and therefore no perforations are necessary to prevent condensation inside the pack ; sufficient air is allowed to pass through the film to keep it crystal clear under most conditions. It is claimed that the free exchange of air through the 'Clarifoil' allows the fruit to 'breathe,' preserving it in garden-fresh condition.

Packaging has become an important feature of the merchandising of consumer goods of all kinds, and fruit and vegetables are no exceptions. Growers have been quick to appreciate the advantages of pre-packing ; it means that they can create a consumer demand for their produce by printing brand names, trade marks, etc., on the carton, and gain a reputation for quality which must show dividends.

The grower can expect more for his mushrooms when they are attractively packed in retail units, and the higher price received should more than cover the cost of the cartons.

The photograph was one taken of these Metal Box/Clarifoil punnets supplied by A. Warne and Co. Ltd., 1-2 Racquet Court, Fleet Street, London, E.C.4.



Regarding the **Recipe Leaflets** prepared for Olympia, please accept these remarks in the spirit in which I make them. I claim to know more about the buyers, the consumers, than some. I have been here since 1888. The mushroom consumers are fully 75% working-class people. They have the cash to spend and they spend it. On Friday, Hubby drops his wage in the wife's pinny. She buys, at 2/- a quarter, mushrooms on toast for Our Jack's tea. The ordinary working class are at a loss to understand, and cannot possibly follow, these recipes. André Simon is without doubt O.K. at a posh restaurant in France—chopped ham, chopped chicken, brush surface of tartlet with yoke of eggs, mould with the hands into a round raised pie, vol-au-vent surprise, noodles with mushrooms, salad de champignons, hors d'œuvre—all this is definitely foreign to 80% of those who consume your mushrooms. If you can, *get some real, good recipes in English.* **J. C. LUCAS.**

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